



OFFICE OF RAIL REGULATION



**Internal guidance on  
cost benefit analysis  
(CBA) in support of  
safety-related  
investment decisions**

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## Purpose of the document

1. The purpose of this guide is to assist ORR staff in assessing whether risks on Britain's railways have been reduced 'so far as is reasonably practicable' (SFAIRP). The guide sets out our view on what should and should not be included in a duty holder's cost-benefit analysis (CBA) for SFAIRP purposes. In this section we explain how to interpret the results of a CBA.
2. In a CBA, all costs and benefits are set out using the same unit of measure, usually money, so that a comparison can be made between different options. It is a defined methodology for valuing costs and benefits that enables broad comparisons to be made between safety risk reduction measures on a consistent basis, increasing transparency in decision making.
3. When safety measures are being considered and:
  - the cost is less than the monetary value of the safety benefit we would expect the improvement to be implemented;
  - the cost is more than the monetary value of the safety benefit, duty holders should make a professional judgement;
  - the cost is grossly disproportionate to the safety benefit, then it is not reasonably practicable to implement the improvement on safety grounds alone; of course, there may be wider business, commercial, strategic, moral or political factors that means the investment nonetheless goes ahead.
4. A CBA cannot form the sole determinant of a SFAIRP decision, nor should it be used as the sole justification for removing existing control measures or good practice.
5. In making this judgement, we would expect particular attention to be applied to:
  - the level of uncertainty in the assessment of costs and safety benefits; and
  - the range of potential safety consequences.
6. We would not generally require schemes with mainly commercial benefits to be used to achieve small safety benefits. However, if duty holders decide (for commercial reasons) to undertake such a scheme, any reasonably practicable modifications which improve safety should be implemented.
7. You should read this guide alongside ORR's guidance and general principles for "Assessing whether risks on Britain's railways have been reduced SFAIRP"<sup>1</sup>. You

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<sup>1</sup> ORR's internal guidance and general principles for "Assessing whether risks on Britain's railways have been reduced SFAIRP' (so far as is reasonably practicable)" can be accessed [here](#)

can also find lots of useful advice and guidance in the Department for Transport's (DfT) web-based transport analysis guidance (WebTAG) which is updated regularly<sup>2</sup>.

## Background

8. The Health and Safety Executive's (HSE), Reducing Risks, Protecting People (R2P2)<sup>3</sup> document discusses reasonable practicability and sets out the expectation that risk reduction action is to be taken using established relevant good practice as a baseline. Where relevant good practice is appropriate to the circumstances, then decisions on risk reduction action are straightforward – see the entry for “Good Practice” in “Assessing whether risks on Britain's railways have been reduced SFAIRP”.
9. In circumstances where established good practice does not already exist, is out of date, or the situation is complicated and the relevance of individual examples of good practice is questionable (for example the combination of discrete hazards is not dealt with in the good practice documents), the decision making process on risk reduction action is less straightforward. CBA aids the decision making process by giving monetary values to the costs and benefits and by enabling a comparison of like quantities. The analysis can help make an informed choice between risk reduction options.
10. For many SFAIRP decisions we do not expect duty holders to undertake a detailed CBA, and a simple comparison of costs and benefits may suffice and thus can help to determine whether or not a particular measure is necessary to ensure safety SFAIRP. Where major health and safety issues are being considered, duty holders may benefit from undertaking a more thorough CBA. Decisions should not be unduly influenced by small changes in the underlying assumptions made in the CBA.

## Costs

11. The costs to be included in the CBA should be the net costs to the duty holder of introducing the safety measure. Only those costs shown to relate to the safety measure being assessed should be included. In general we would expect these costs to include:
  - a) Costs of installation, operation, training, any additional maintenance, and other costs (for example, possessions compensation payments on the mainline railway<sup>4</sup>) that would result from suspending any

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<sup>2</sup> WebTAG guidance can be accessed [here](#)

<sup>3</sup> The Health and Safety Executive's (HSE), “Reducing Risks, Protecting People” document is available [here](#)

<sup>4</sup> On the mainline railway train operators are compensated through Schedule 4 of their track access agreement when Network Rail takes possession of the railway, for example due to engineering works. Schedule 4 provides compensation for revenue losses and some costs.

services, for example for the purposes of putting the measure in place.

- b) Only those costs incurred by the duty holder (costs incurred by other parties, for example members of the public, should not be counted). However, the costs to the duty holder should include the costs of mitigating measures, for example compensation. Costs associated with passenger inconvenience or using alternative transport that are not incurred by the duty holder should not be included.
  - c) An appropriate allowance in scheme costs for optimism bias<sup>5</sup>.
  - d) Ongoing revenue losses as a result of the measure (for example if trains are slowed down).
12. Any savings as a result of the measure (for example reduced operational costs such as avoiding damage and reinstatement costs, if relevant; or for the mainline network, those due to reduced performance regime compensation payments where these are significant<sup>6</sup>) should be offset against the above costs. These are not considered safety benefits but are counted as cost savings that is they reduce the overall cost of putting a measure in place.
13. Where revenue losses are a strong influence on a decision not to implement a measure, the duty holder should show that phasing or scheduling the work to coincide with planned closures (for example closing the line for maintenance) would not change the decision. Duty holders should try and implement the measures on trains when they are already being maintained or on the infrastructure when it is not being used or is already closed for other reasons. This would minimise the costs associated with the trains or network not being used.
14. Converting costs into monetary values is often uncertain and all costs should be justified.

## Financing Costs

15. Financing costs should be included in the CBA to reflect that if a firm invests £100 in a piece of safety equipment, it is unlikely that the total cost of this investment for the private firm was £100 exactly. For example, if the firm has had to borrow this money from a bank, it will also have interest payments on that £100, and may incur arrangement fees.

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<sup>5</sup> Further details on optimism bias are included in the Treasury Green Book, and unit A1-2 on scheme costs in WebTAG unit A1.2. The Treasury Green Book can be accessed [here](#)

<sup>6</sup> On the mainline railway train operators are compensated through Schedule 8 of their track access agreement for revenue losses due to lateness and cancellations attributed to Network Rail or other train operators.

16. If the estimate of the private financing costs was much lower than the actual costs, or if these costs were completely ignored, it would cause the costs of the project to be underestimated.
17. The stream of capital finance payments included in the CBA should reflect an estimate of the actual costs that the duty holder faces. Further information on how to calculate the stream of finance cost payments can be found in the example calculation below.
18. As the NERA report on 'Discount Rates for Rail Safety Scheme Appraisals'<sup>7</sup> explains, for private firms the financing costs may be included in market prices. In this case, it is not necessary to attempt to add it to the CBA. When this is not the case, an estimate of the rate of return that would be paid on this financing will be required as well as assumptions about how these payments will be distributed over time. This is important as we value money in one time period differently to money in another time period.
19. For a regulated company, it may be reasonable to assume that an investment could be an addition to the regulated asset base and therefore its relevant cost of capital, as determined by the regulator, could be used to estimate financing costs.
20. However, it is important to remember that the most relevant estimate of the duty holder's costs incurred due to the safety measure should be used.
21. Irrespective of how the financing costs are estimated they should be discounted using the discount rate explained below.

## Benefits

22. The benefits to be included in the CBA are the benefits in terms of improved health and safety. This should include all the reduction in risk to passengers, workers and members of the public. Only those risk reductions shown to relate to the safety measure being assessed should be included.
23. Where possible, the changes to risk should be estimated using an appropriate risk model. Where risks are difficult to quantify, a similar depth of analysis might be applied using qualitative techniques such as structured workshop assessments supported by expert judgement.

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<sup>7</sup> The NERA report on 'Discount Rates for Rail Safety Scheme Appraisals' can be found on the ORR website [here](#)

24. Health and safety benefits in a railway context should be valued using the most recent WebTAG guidance<sup>8</sup>. Following the guidance, this consists of two stages:

- First, the health and safety benefits are quantified using the metric “fatalities and weighted injuries” (FWI). The guidance sets the statistical values of major and minor injuries in relation to the value of preventing a fatal injury. For the mainline network for major injuries it is currently 1/10 of the statistical fatality value and for reportable minor injuries (and Class 1 shock trauma) it is 1/200 of the fatality value. For non-reportable minor injuries (and Class 2 shock / trauma) it is 1/1000 of the fatality value.
- Second, the total FWI are monetised by applying the value of preventing a statistical fatality (VPF). The November 2014 WebTAG guidance is set out in the table below. Note that this is in 2010 prices and values.

Table A 4.1.1: Average value of prevention per casualty by severity and element of cost £ (2010 prices and 2010 values)				
Casualty type	Lost output	Human costs	Medical & ambulance	Total
Fatal	563,822	1,075,344	968	1,640,134
Serious	21,722	149,423	13,160	184,305
Slight	2,296	10,939	974	14,208
Average, all casualties	9,823	37,195	2,411	49,429

25. HSE provides values for wider health and safety impacts, including ill-health, and these values should be used when assessing impacts in a non-railway context<sup>9</sup>.

## Using a consistent price base

26. To carry out a CBA, where possible costs and benefits should be expressed in monetary terms. However, even where costs and benefits are both in monetary values they still may not be on a comparable basis. To ensure consistency, the costs and benefits should be expressed in:

- Market prices, i.e. gross of VAT;
- Real terms, using a consistent price base e.g. 2015 prices; and
- Consistent values.

27. In an economy with indirect taxes, the monetary values can be either at factor cost (that is, excluding indirect tax such as VAT) or at market prices (that is, including

<sup>8</sup> This guidance is updated regularly so always ensure you are using the latest version. The information on value of fatalities can be accessed via unit A4.1 in the WebTAG databook tab A4.1.1. [here](#).

<sup>9</sup> These values are taken from [here](#). HSE values are based on different definitions for major and minor injuries to the railway specific values listed above.

indirect tax)<sup>10</sup>. Public and private sector providers typically pay costs at factor cost, because they are exempt of VAT. Health and safety benefits are based on people's willingness to pay and so are at market prices. Costs and benefits should be assessed consistently using market prices and so the safety measure's costs, where they do not already include tax, should be converted into the market prices by multiplying by the indirect taxation correction factor which is 1.190<sup>11</sup>.

28. The application of this factor is described in the example below.
29. To allow values to be comparable across different years the prices of the safety measure's costs and benefits need to be expressed in 'real terms' (i.e. at a common price level). This removes the impact of inflation. In practice, this means selecting a price base, e.g. 2014 prices, and adjusting costs that are calculated using a different price base using an inflation index. For more information on converting prices into real terms, please see the Treasury Green Book<sup>12</sup>.
30. The prices in the example calculation below have already been converted into real terms as they are in 2010 prices.
31. Health and safety impacts also need to be adjusted over time for changing monetary values brought about by changes to income levels. Current Treasury guidance is to assume real GDP per capita growth of around 2% a year, implying that the value of preventing a fatality should be increased by 2% a year in real terms.
32. For example, if using WebTAG the value of preventing a fatality will be in 2010 values. If the investment occurs in 2015 and you are therefore using 2015 as your price base, the 2010 value needs to be inflated by 2% a year for five years, i.e. by  $(1.02)^5$ .

## Discounting

33. If the costs and benefits of the measure take place over time, they need to be brought together into a single present value by discounting future costs and benefits.
34. The law imposes health and safety obligations on duty holders because of the benefits this provides to society. We therefore consider that costs and benefits should be discounted using public sector discount rates. Future costs and cost

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<sup>10</sup> A description of market prices and factor costs information can be found within appendix B of DfT's WebTAG, unit A1.1.

<sup>11</sup> This number comes from the WebTAG Data book; sheet A1.3.1, November 2014 which can be found [here](#). This data is updated regularly so you should ensure you are using the latest version.

<sup>12</sup> See page 25 of The Treasury Green Book.



savings should be discounted at 3.5% per year for the first 30 years and 3.0% per year until year 75 of the appraisal<sup>13</sup>.

35. The value of future health and safety benefits has a constant utility value over time and is therefore increased in real terms each year by real GDP per capita growth. Current real GDP per capita growth is around 2% a year<sup>14</sup> which, coupled with a discount rate of 3.5%, gives an effective discount rate for health and safety benefits of 1.5% a year for the first 30 years and 1% a year for the next 45 years.
36. As there is a robust rationale behind why these discount rates should be used a duty holder would need to provide a detailed explanation if they were to use a different discount rate in their CBA.
37. Costs and benefits should be assessed over the life of the measure. For example if the measure is expected to last 10 years before it is replaced then costs and benefits should be taken into account for a ten-year period. The benefits of an investment should be calculated over the life of the asset even if this extends beyond a franchise period.
38. We consider that assessment periods of 50 years or more can be problematic. If a measure requires a long assessment period then this should be treated with caution and sensitivity tests should be carried out using shorter appraisal periods.

## Treatment of risk and uncertainty

39. When carrying out a CBA, duty holders are likely to have limited information about some of the main inputs such as the frequency of events and the likely consequences. Costs and risk estimates are therefore subject to uncertainty. Duty holders should provide best estimates and adequate justification for the numbers they have used. We would expect duty holders to conduct sensitivity tests to identify how the CBA would be affected by changes in those inputs where there is uncertainty. Sensitivity analysis consists of varying one or more of the parameters/assumptions of the CBA to see how these variations affect the CBA outcomes. We would expect sensitivity tests to include an assessment of costs with and without risk allowances and optimism bias<sup>15</sup>. As described above, the judgement of what is reasonably practicable should take into account the results of the sensitivity tests and the level of uncertainty about costs and safety benefits.

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<sup>13</sup> See annex 6 of the Treasury Green Book.

<sup>14</sup> This 2% real GDP per capita growth is also a component of the 3.5% discount rate as explained in the Treasury Green Book. It is to reflect the assumption that for most types of consumption, a small increase in consumption for a generation with double the income of the current generation will only have half the value that it does to the current generation.

<sup>15</sup> Further details on optimism bias are included in the Treasury Green Book, and in a rail specific context from para 2.5 of Unit A5.3 of WebTAG.

## Document provenance

40. This guide has been produced following a review and update of the previous guidance, which was published in 2008. That guidance was in turn a replacement of guidance issued by Her Majesty's Railway Inspectorate (HMRI) on cost benefit appraisal, in particular "HMRI specific cost benefit checklist" and the use in a railway context of "HSE principles for Cost Benefit Analysis in support of ALARP decisions".

## Worked example

41. Table 1 on the following page provides a worked example of a safety scheme CBA using the above criteria.

### Costs

42. The CBA assumes that the scheme costs a total of £5 million (including risk) in 2010 prices. Converting these costs to market prices (by multiplying by 1.190) increases the costs from £5 million to £5.95 million.
43. Total scheme costs will be a combination of the financing costs and the capital repayments. The following approach makes a number of simplifications but we consider that these are reasonable for appraisal purposes.

### Financing costs and capital repayments

44. As a simplification we can assume the capital repayment profile is equal to the depreciation of the asset over its lifetime. Depreciation reflects the decline in the value of assets over time. If we assume straight-line depreciation (the asset declines in value by an equal amount each year over its lifetime) then with an asset life of 10 years and with a cost of £5.95million this would give annual depreciation of £0.595 million a year over 10 years ( $5.95 \text{ million} / 10 = 0.595 \text{ million}$ ).
45. As explained above the financing cost of the investment in this example, is the cost of financing the outstanding net book value. Therefore, in year two the net book value of the scheme would be £5.355 million, i.e. the original cost of £5.95 million minus the first year amortisation of £0.595 million. Assuming a real cost of finance of 6% per year gives a financing cost of £0.357 million in year one ( $0.06 \times £5.95\text{million}$ ).

### Benefits

46. The scheme is estimated to save the equivalent of 0.6 of a statistical fatality a year over the 10 years of the lifetime of the scheme. The statistical value of a prevented fatality is £1.636 million in 2010 prices<sup>16</sup>. In this example, both the costs and benefits

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<sup>16</sup> This number comes from the WebTAG Databook, sheet A4.1.5, May 2014. This data is updated regularly so you should ensure you are using the latest version.

are in quoted in 2010 prices. If the value of the fatality was in 2007 prices, this would need to be increased to 2010 prices by increasing the value in line with nominal growth in GDP per capita. With 0.6 of a statistical fatality a year this gives annual benefits of £0.980 million a year in 2010 prices.

## Calculation

47. To bring costs and benefits together they are discounted to the current year. In accordance with this guidance, scheme costs have been discounted at 3.5% and the scheme benefits at 1.5% over the 10-year period.
48. Overall the benefit to cost ratio of the safety scheme is 1.4:1, meaning that benefits outweigh costs. As a result we would expect the scheme to be reasonably practicable and provide a positive input into the final safety decision-making process.

	£m (2010 Prices)	Source	Total	Year										
				0	1	2	3	4	5	6	7	8	9	10
A	Costs	Para 43		5.95										
B	Net Book Value	Para 46		5.95	5.95	5.36	4.76	4.17	3.57	2.98	2.38	1.79	1.19	0.60
C	Capital Repayment	Para 45			0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
D	Financing costs	Para 46			0.36	0.32	0.29	0.25	0.21	0.18	0.14	0.11	0.07	0.04
E	Total costs	C+D			0.95	0.92	0.88	0.84	0.81	0.77	0.74	0.70	0.67	0.63
F	Discount factor @3.5%	Para 48		1	0.97	0.93	0.90	0.87	0.84	0.81	0.79	0.76	0.73	0.71
G	Discounted costs	E x F	6.67	0.00	0.92	0.86	0.79	0.74	0.68	0.63	0.58	0.53	0.49	0.45
H	Benefits	Para 47			0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
I	Discount factor @1.5%	Para 48		1	0.99	0.97	0.96	0.94	0.93	0.91	0.90	0.89	0.87	0.86
J	Discounted benefits	H x I	9.04	0	0.97	0.95	0.94	0.92	0.91	0.90	0.88	0.87	0.86	0.84
K	Benefit cost ratio	J/G	1.36											

**Table 1: Example of Safety Scheme Appraisal**



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